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EVALUATING CONTINUOUS REVIEW AND PERIODIC REVIEW SYSTEMS FOR BOTTLED WATER RAW MATERIAL INVENTORY MANAGEMENT

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Abstract

Intuition-based inventory planning at PT XYZ, a brand-owning bottled water company, has led to inventory imbalances resulting in overstocking and stockouts that trigger cost inefficiencies. This study aims to perform a comparative analysis between the company's actual policy, the Continuous Review System (Q-System), and the Periodic Review System (P-System) methods to optimize inventory costs. The research utilizes a quantitative comparative approach on 330 mL and 600 mL variants using 2025 operational data. The results indicate that the Q-System can reduce operational costs by up to 33,62%, while the P-System only yields marginal cost savings of 4,04% compared to the actual method. For both the 330 mL and 600 mL variants, the Q-System proved to be the definitively superior model by maintaining a much smaller, yet highly secure safety stock. In conclusion, the company is advised to fully transition its inventory policy to the Q-System to minimize physical holding costs while effectively eliminating the expensive risk of stockouts in a volatile market.

Keywords: Continuous Review System, Inventory cost, Inventory planning, Periodic Review System, Safety stock

INTRODUCTION

Every Fast-Moving Consumer Goods (FMCG) company has one fundamental operational goal, which is to ensure that people's daily needs are always met without sacrificing the company's financial stability (Henríquez-Machado et al., 2021; Shakur et al., 2024). To achieve this goal, companies must manage their logistics flow effectively to avoid two major threats: overstocking, which wastes storage costs in warehouses, or stockouts, which result in lost potential profits and customer trust (Nurprihatin et al., 2022). Therefore, managing inventory levels to respond to daily market demand fluctuations is essential for every FMCG company. However, many companies continue to adopt traditional approaches, operating under the assumption that market conditions will always be stable and easily predictable (Holloway, 2024). Nevertheless, this assumption of stability is often the primary cause of planning errors. Consumer behaviour in the real world is highly dynamic and subject to random fluctuations (stochastic). Conventional approaches simply cannot respond to market fluctuations. What companies need is an operational analysis framework that can both measure physical availability and calculate the financial risk during demand spikes (Istiningrum et al., 2021). This emphasizes the need to update inventory methods to be more sensitive to the probability of actual losses for the company.

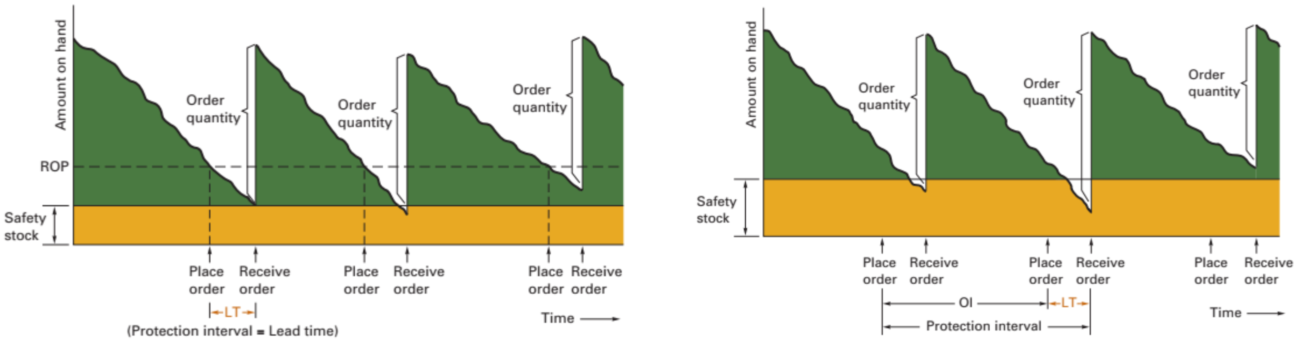
Updating this inventory management method is particularly crucial given the unique characteristics of bottled drinking water products. For these products, warehouse storage costs are relatively low, but the cost of stockouts is extremely high because consumers can easily switch to competing brands (Nurprihatin et al., 2022). As a bottled water manufacturer, PT XYZ is facing an inventory challenge due to uncertainty regarding delivery times of logistics shipments from suppliers. The company must switch to a calculation method that can balance storage costs and actual financial losses. Otherwise, the threat of losing customers due to stockouts will continue to risk the business's sustainability. To address these operational challenges, the problem-solving approach focuses on comparing advanced probabilistic inventory control methods, such as the Continuous Review System (Q-System) and the Periodic Review System (P-System). Unfortunately, research comparing the performance of these two systems using actual shortage cost optimization calculations in the bottled water industry remains very limited. This study aims to evaluate and compare the Total Inventory Cost (TIC) for 330 mL and 600 mL products at PT XYZ using the Q-System and P-System. The results of this study, based on measurable mathematical calculations, are expected to provide recommendations for the most cost-effective ordering schedule policy to mitigate the risk of stockouts for the company.

LITERATURE REVIEW

Traditional inventory models such as Economic Order Quantity (EOQ) have proven to have a major flaw because they are based on the assumption that market demand is always constant (Andriolo et al., 2014; Lok et al., 2022). The approach has shifted toward probabilistic modelling, which is more relevant to real-world uncertainty in the face of unexpected order spikes. In modern probabilistic modelling, the focus of calculations is no longer merely on minimizing physical holding costs but directly incorporates the variable of shortage cost (Stevenson, 2015). This cost reflects the financial loss resulting from lost potential sales when warehouse inventory is depleted (Furtyfatimah et al., 2023). The use of this loss ratio as the primary benchmark allows probabilistic models to determine the economically optimal safety stock level, thus preventing stockouts.

The basic concepts of operations management divide inventory control systems into two categories, the Continuous Review System (Q-System) and the Periodic Review System (P-System) (Ernawati et al., 2025). The fundamental difference between these two methods lies in how companies determine when to place orders and calculate the quantity of goods to be ordered (Stevenson, 2015). As shown in Figure 1, Q-System is event-triggered, meaning that a fixed quantity (Q) of new orders is placed immediately whenever the inventory level drops to the reorder point (ROP) (Heizer et al., 2017). In contrast, the P-System is time-triggered, with orders placed at pre-set review intervals (T).

Due to the differences in the mechanisms of these two systems, it is no longer possible to determine inventory targets through manual estimates or one-time static calculations. Previous studies have shown that such calculations often lead to decision-making biases because they fail to dynamically balance savings on holding costs with the high financial penalties resulting from shortage costs (Sarkar et al., 2015). To address this methodological weakness, recent studies use mathematical iterative algorithms that can repeatedly calculate order quantities and stockout probabilities until the most economically optimal convergence point is reached (Lin, 2010). While these algorithms are widely recognised for their ability to optimise Total Inventory Cost, research comparing their application to the real-world efficiency of the Q-System and P-Systems in FMCG sector is limited. This study aims to address this research gap by conducting a mathematical comparative evaluation to determine the most efficient control system for the 330 mL and 600 mL product lines at PT XYZ.



(a) (b)

Figure 1 (a) Q System, (b) P System
Heizer et al. (2017)

METHOD

Research Type and Object

This study adopted a comparative quantitative approach. The object of the research was PT XYZ, a manufacturing company operating in the bottled drinking water industry. The company produces four product variants: 220 mL, 330 mL, 600 mL, and 19 L. From these, the 330 mL and 600 mL variants were selected through purposive sampling to accurately represent actual operational conditions. The research stages encompassed historical data collection, demand variability measurement, and actual inventory cost evaluation. Inventory optimization was then simulated using Q-System and P-System. The primary parameters analyzed included order quantity (Q), review interval (T), safety stock (SS), reorder point (ROP), and maximum inventory level (I_{max}). The final evaluation compared the TIC of both systems to determine the most effective approach for minimizing expenses and mitigating demand uncertainty.

Data Collection Methods

Data collection was conducted through an analysis of internal company documents. The data included operational records from January to December 2025 to ensure that actual demand variations are accurately captured. The basic variables collected include total annual demand (D), order size for each purchase (Q_{actual}), ordering cost per setup (S), holding cost per unit per year (H), and the company's historical order quantity (Q). As complementary data, additional parameters were also collected, including average daily demand (d), lead time (L), total annual working days, and shortage cost (C_S).

Data Analysis Methods

Data analysis is carried out in four main stages. The first stage measures the level of demand fluctuation by calculating the sample standard deviation (σ) using equation (1), where n is the number of periods, X_i is the actual demand in period i, and $\bar{X}$ is the average demand over the n periods.

$$\sigma = \sqrt{\frac{\sum (X_i - \bar{X})^2}{n - 1}} \tag{1}$$

The second stage evaluates the TIC of the company's actual method to serve as an initial baseline. This calculation is based entirely on the company's actual order frequency (F_{actual}) and the average warehouse inventory, which is calculated as half of the actual order quantity ($\frac{Q_{actual}}{2}$). The TIC_{actual} is calculated using Equation (2) as follows:

$$TIC_{actual} = [F_{actual} \times S] + \left[\frac{Q_{actual}}{2} \times H\right] \tag{2}$$

The third stage applies the Q-system to determine optimal ordering parameters under demand uncertainty. The process begins with determining the initial order quantity (Q) as the primary decision variable, which is iteratively refined to obtain the optimal value (Q_i). The probability of stockout (P) represents the risk of inventory shortages, while the expected shortage (E(S)) indicates the average unmet demand during each cycle. Demand variability during lead time is captured by the standard deviation (σ_L) which is used to determine the safety stock (SS_Q) as a buffer against uncertainty. The reorder point (ROP) is then established based on the expected demand during lead time and the safety stock. Finally, the total inventory cost (TIC_Q) is evaluated by integrating ordering, holding, and shortage costs. The calculations for the third stage use Equations (3) – (9),

$$Q = \sqrt{\frac{2 \times D \times S}{H}} \tag{3}$$

$$P = \frac{H \times Q}{C_S \times D} \tag{4}$$

$$E(S) = \sigma_L \times L_{(z)} \tag{5}$$

$$Q_i = \sqrt{\frac{2D(\, S + C_s \times E(S))}{H}} \tag{6}$$

$$SS_Q = Z \times \sigma_L \tag{7}$$

$$ROP = SS_Q + \,(d \times L) \tag{8}$$

$$TIC_Q \;= \left(\frac{D}{Q}\right) S + \left(\frac{Q}{2} + SS_Q\right) H + \left(\frac{D}{Q} \times C_S \times E(S)\right) \tag{9}$$

The fourth stage applies P-System. This method determines I_{max} based on the expected demand during the protection interval (T+L) and the safety stock (SS_P). The safety stock is designed to protect inventory against uncertainty during both the review intervals (T) and lead time (L), and is calculated using the combined standard deviation (σ_{T+L}) which id derived from the daily standar deviation σ_d and the desired service level. Furthermore, this step determines the expected shortage per cycle (N_P) using the standard normal loss function ($L_{(z)}$). The Total Inventory Cost (TIC_P) is calculated by integrating ordering, holding, and shortage costs. The calculations for the P-system use Equations (10) – (15).

$$\sigma_{T+L} = \sigma_d \times \sqrt{T+L} \tag{10}$$

$$P = \frac{H \times T}{C_S} \tag{11}$$

$$SS_P = Z \times \sigma_{T+L} \tag{12}$$

$$I_{max} = SS_P + d\,(T + L) \tag{13}$$

$$N_P = \sigma_{T+L} \times L_{(z)} \tag{14}$$

$$TIC_P = \left(\frac{1}{T}\right) S + \left(\frac{D \times T}{2} + SS_p\right) H + \left(\frac{1}{T}\right) \times C_S \times N_P \tag{15}$$

The final evaluation is done by comparing the inventory cost performance (TIC) of the company's actual method (Equation 2), the Q-system (Equation 9), and the P-system (Equation 15). This comparative analysis will serve as the foundation for recommending the most optimal inventory control system in terms of cost efficiency and safety stock security for PT XYZ's operations.

RESULTS AND DISCUSSION

Standard Deviation

The first stage in this inventory modeling is measuring demand fluctuation through the standard deviation (s) using Equation (1). The company's operational data over 12 months (January to December 2025) recorded a total demand (D) of 340.536 units for the 330 mL variant and 169.992 units for the 600 mL variant. The company operates with 22 effective working days per month, which is equivalent to 264 working days per year (N = 264). Considering that standard deviation follows the law of variance, converting the monthly deviation to a daily basis is done by dividing it by the square root of the number of working days ($\sqrt{22}$). The standard deviation calculation results are presented as follows:

- For 330 mL

$$\sigma = \sqrt{\frac{\sum (X_i - \bar{X})^2}{n - 1}} = \sqrt{\frac{1.372.641.936}{11}} = 11.170{,}74 \approx 11.171 \text{ unit}$$

Daily Standard Deviation

$$\sigma_d = \frac{\sigma}{\sqrt{\text{Number of Working days in a Month}}} = \frac{11.171}{\sqrt{22}} = 2.381{,}\ 61 \approx 2.382 \text{ unit}$$

Standard Deviation for Lead Time

$$\sigma_L = \sigma_d \times \sqrt{L} = 2.382 \times \sqrt{5} = 5.326{,}31 \approx 5.327 \text{ unit}$$

- For 600 mL

$$\sigma = \sqrt{\frac{\sum (X_i - \bar{X})^2}{n - 1}} = \sqrt{\frac{156.575.376}{11}} = 3.772{,}81 \approx 3.773 \text{ unit}$$

Daily Standard Deviation

$$\sigma_d = \frac{\sigma}{\sqrt{\text{Number of Working days in a Month}}} = \frac{3.773}{\sqrt{22}} = 804{,}406 \approx 805 \text{ unit}$$

Standar Deviation for Lead Time

$$\sigma_L = \sigma_d \times \sqrt{L} = 805 \times \sqrt{5} = 1.800{,}035 \approx 1.801 \text{ unit}$$

The calculation results show that the 330 mL variant has a demand standard deviation of 11.171 units (2.382 units (daily)) and a lead time standard deviation of 5.327 units. Meanwhile, the 600 mL variant exhibits lower fluctuations, with a demand standard deviation of 3.773 units (805 units (daily)) and a lead time standard deviation of 1.801 units.

Actual Method (Baseline)

The second stage evaluates the cost performance of the company's actual inventory method (TIC_{actual}) using Equation (2). Based on company policy, the order size for each purchase is fixed (Q_{actual} = 9.600 unit). The historical average inventory is evaluated based on the midpoint of that order quantity ($\frac{Q_{actual}}{2}$ = 4.800 unit). Meanwhile, the ordering cost is calculated from the ratio of total historical purchases to the order quantity. For the 330 mL size, orders of 9.600 units were made with a frequency of 35 orders, while the 600 mL size had a frequency of 26 orders. For each of these orders, company records indicate a uniform S of Rp131.706 per setup across both product lines. In contrast, the H depends on the variant, amounting to Rp 64 per unit per year for the 330 mL size and Rp 136 per unit per year for the 600 mL size. The results of this actual inventory cost calculation are presented as follows:

- For 330 mL

  $F_{actual} = 35$ orders/year

  $$TIC_{actual} = (F_{actual} \times S) + \left[\frac{Q_{actual}}{2} \times H\right]$$

  $$TIC_{actual} = (35 \times 131.706) + (4.800 \times 64) = 4.609.710 + 307.200 = Rp4.916.910$$

- For 600 mL

  $F_{actual} = 26$ orders/year

  $$TIC_{actual} = (F_{actual} \times S) + \left[\frac{Q_{actual}}{2} \times H\right]$$

  $$TIC_{actual} = (26 \times 131.706) + (4.800 \times 136) = 3.424.356 + 652.800 = Rp4.077.156$$

Based on the operational parameters above, the calculation yields an actual total inventory cost (TIC_{actual}) of Rp4.916.910 for the 330 mL variant. Meanwhile, for the 600 mL variant, the evaluation results TIC_{actual} of Rp4.077.156.

Continuous Review System Analysis (Q-System)

In the third stage, the inventory analysis is conducted using the Q-System method. The primary focus of this stage is to determine Q, P, and (E(S)) using Equations (3), (4), and (5). The calculations incorporate additional parameters, including a lead time of 5 days and shortage costs (C_S) of Rp504 for the 330 mL product and Rp508 for the 600 mL product. The detailed calculations are presented as follows:

Iteration 1

- For 330 mL

  $$Q_1 = \sqrt{\frac{2 \times D \times S}{H}} = \sqrt{\frac{2 \times 340.536 \times 131.706}{64}} = 37.437,71 \approx 37.438 \text{ unit}$$

  $$P_{(z)(1)} = \frac{H \times Q_1}{C_S \times D} = \frac{64 \times 37.438}{504 \times 340.536} = 0,0140$$

  $$\Phi_{(z)(1)} = 1 - P_{(z)(1)} = 1 - 0,0140 = 0,986$$

  $(Z)_{(1)} = 2,198$ (from Z-table)

  $$L_{(z)(1)} = \emptyset_{(z)} - (Z)_{(1)}\left[1 - \Phi_{(z)(1)}\right] = 0,0345 - (2,198 \times 0,0140) = 0,0049$$

  $$E(S)_{(1)} = \sigma_L \times L_{(z)(1)} = 5.327 \times 0,0049 = 26,152 \approx 27 \text{ unit}$$

- For 600 mL

  $$Q_1 = \sqrt{\frac{2 \times D \times S}{H}} = \sqrt{\frac{2 \times 169.992 \times 131.706}{136}} = 18.145,23 \approx 18.146 \text{ unit}$$

  $$P_{(z)(1)} = \frac{H \times Q_1}{C_S \times D} = \frac{136 \times 18.146}{508 \times 169.992} = 0,0286$$

  $$\Phi_{(z)(1)} = 1 - P_{(z)(1)} = 1 - 0,0286 = 0,9714$$

  $(Z)_{(1)} = 1,9$ (from Z-table)

  $$L_{(z)(1)} = \emptyset_{(z)} - (Z)_{(1)}\left[1 - \Phi_{(z)(1)}\right] = 0,065 - (1,9 \times 0,0286) = 0,011$$

  $$E_{(s)(1)} = \sigma_L \times L_{(z)(1)} = 1.801 \times 0,011 = 19,799 \approx 20 \text{ unit}$$

Based on the results of Iteration 1, the inventory parameters for each product size are obtained. For the 330 mL product, Q_1 is 37.438 units, $P_{(z)(1)}$is 0,0140, and $E_{(s)(1)}$ is 27 units. Meanwhile, for the 600 mL product, the Q_1 is 18.146 units, $P_{(z)(1)}$is 0,0286, and the expected shortage $E_{(s)(1)}$ is 20 units. Subsequently, the analysis proceeds to Iteration 2. In this stage, the determination of Q_2 is carried out using Equation (6), which incorporates the expected shortage value obtained from the previous iteration. The detailed calculations are presented as follows:

Iteration 2

- For 330 mL

$$Q_2 = \sqrt{\frac{2D\,(S + C_S \times E_{(s)(1)})}{H}} = \sqrt{\frac{2 \times 340.536 \times (131.706 + 504 \times 27\,)}{64}} = 39.324,23 \approx 39.325 \text{ unit}$$

$$P_{(z)(2)} = \frac{H \times Q_2}{C_S \times D} = \frac{64 \times 39.325}{504 \times 340.536} = 0,0147$$

$$\Phi_{(z)(2)} = 1 - P_{(z)(2)} = 1 - 0,0147 = 0,985$$

$$(Z)_{(2)} = 2,179 \text{ (from Z-table)}$$

$$L_{(z)(2)} = \emptyset_{(z)} - (Z)_{(2)}\left[1 - \Phi_{(z)(2)}\right] = 0,037 - (2,179 \times 0,0146) = 0,0052$$

$$E_{(s)(2)} = \sigma_L \times L_{(z)(2)} = 5.327 \times 0,0052 = 27,627 \approx 28 \text{ unit}$$

- For 600 mL

$$Q_2 = \sqrt{\frac{2D\,(S + C_S \times E_{(s)(1)})}{H}} = \sqrt{\frac{2 \times 169.992 \times (131.706 + 508 \times 20\,)}{136}} = 18.832,10 \approx 18.833 \text{ unit}$$

$$P_{(z)(2)} = \frac{H \times Q_2}{C_S \times D} = \frac{136 \times 18.833}{508 \times 169.992} = 0,0296$$

$$\Phi_{(z)(2)} = 1 - P_{(z)(2)} = 1 - 0,0296 = 0,9704$$

$$(Z)_{(2)} = 1,886 \text{ (from Z-table)}$$

$$L_{(z)(2)} = \emptyset_{(z)} - (Z)_{(2)}\left[1 - \Phi_{(z)(2)}\right] = 0,0673 - (1,886 \times 0,0296) = 0,0115$$

$$E_{(s)(2)} = \sigma_L \times L_{(z)(2)} = 1.801 \times 0,0115 = 20,65 \approx 21 \text{ unit}$$

The calculations in Iteration 2 result in further adjustments. For the 330 mL product, Q_2 increases to 39.325 units, $P_{(z)(2)}$ becomes 0,0147, and $E_{(s)(2)}$ becomes 28 units. For the 600 mL product, the value of Q_2 changes to 18.833 units, with $P_{(z)(2)}$ increasing to 0,0296 and $E_{(s)(2)}$ to 21 units. At this stage, the iteration process is completed and is followed by the final calculation stage. In this stage, the calculation of Q_3 continues to use Equation (6), with additional computations to determine SS, ROP, and TIC, which are calculated sequentially using Equations (7), (8), and (9). The detailed calculations are presented as follows:

- For 330 mL

$$Q_3 = \sqrt{\frac{2D\,(S + C_S \times E_{(s)(2)})}{H}} = \sqrt{\frac{2 \times 340.536 \times (131.706 + 504 \times 28\,)}{64}} = 39.392,36 \approx 39.393 \text{ unit}$$

$$(Z)_{(3)} = 2,178 \text{ (from Z-table)}$$

$$SS_Q = Z \times \sigma_L = 2,178 \times 5.327 = 11.604,14 \approx 11.605 \text{ unit}$$

$$d = \frac{D}{\text{Number of Working Days in a Year}} = \frac{340.536}{264} = 1.290 \text{ unit per day}$$

$$ROP = SS_Q + (d \times L) = 11.605 + (1.290 \times 5) = 18.054,54 \approx 18.055 \text{ unit}$$

$$TIC_Q = \left(\frac{D}{Q}\right)S + \left(\frac{Q}{2} + SS_Q\right)H + \left(\frac{D}{Q} \times C_S \times E_{(s)(2)}\right)$$

$$TIC_Q = \left(\frac{340.536}{39.393}\right)131.706 + \left(\frac{39.393}{2} + 11.605\,\right)64 + \left(\frac{340.536}{39.393} \times 504 \times 28\right) = \text{Rp}3.263.832 \text{ per year}$$

- For 600 mL

$$Q_3 = \sqrt{\frac{2D\,(S + C_S \times E_{(s)(2)})}{H}} = \sqrt{\frac{2 \times 169.992 \times (131.706 + 508 \times 21)}{136}} = 18.865,79 \approx 18.866 \text{ unit}$$

$$(Z)_{(3)} = 1,885 \text{ (from Z-table)}$$

$$SS_Q = Z \times \sigma_L = 1,885 \times 1.801 = 3.391 \approx 3.395 \text{ unit}$$

$$d = \frac{D}{\text{Number of Working Days in a Year}} = \frac{169.992}{264} = 644 \text{ unit per day}$$

$$ROP = SS_Q + (d \times L) = 3.395\ + (644 \times 5) = 6.614,54 \approx 6.615 \text{ unit}$$

$$TIC_Q = \left(\frac{D}{Q}\right)S + \left(\frac{Q}{2} + SS_Q\right)H + \left(\frac{D}{Q} \times C_S \times E_{(s)(2)}\right)$$

$$TIC_Q = \left(\frac{169.992}{18.866}\right) 131.706 + \left(\frac{18.866}{2} + 3.395\right) 136 + \left(\frac{169.992}{18.866} \times 508 \times 21\right) = \text{Rp}3.027.468 \text{ per year}$$

Based on the results of the final calculations, the optimal inventory policy is determined. For the 330 mL product, Q_3 is set at 39.393 units, with a SS_Q of 11.605 units. ROP is established at 18.055 units, resulting in TIC_Q of Rp3.263.832. Meanwhile, for the 600 mL product, the Q_3 is determined to be 18.866 units, with SS_Q of 3.395 units. ROP is set at 6.615 units, yielding TIC_Q of Rp3.027.468. Based on the optimization of the order size and safety limit above, the total inventory cost for the 330 mL variant was successfully reduced from Rp4.916.910 to Rp3.263.832, and for the 600 mL variant from Rp4.077.156 to Rp3.027.468.

Periodic Review System Analysis (P-System)

In the fourth stage, the inventory analysis is conducted using the P-System method. At this stage, the calculations focus on determining several key parameters, including P, SS_P, I_{max}, N_P, and TIC_P, which are calculated sequentially using Equations (11) through (15). The analysis also incorporates additional parameters, including L = 5 days and C_S of Rp504 for the 330 mL product and Rp508 for the 600 mL product. The detailed calculations are presented as follows:

- For 330 mL

$$T_{(Year)} = \frac{Q_3}{D} = \frac{39.393}{340.536} = 0{,}116 \text{ Year}$$

$$T_{(Daily)} = 0{,}116 \times 264 = 31 \text{ Days}$$

$$\sigma_{T+L} = \sigma_d \times \sqrt{T_{(Daily)} + L} = 2.382 \times \sqrt{31 + 5} = 14.292 \text{ unit}$$

$$P_{(z)} = \frac{H \times T_{(Year)}}{C_S} = \frac{64 \times 0{,}116}{504} = 0{,}0147$$

$$\Phi_{(z)} = 1 - P = 1 - 0{,}0147 = 0{,}985$$

$$(Z) = 2{,}178 \text{ (from Z-table)}$$

$$L_{(z)} = \varnothing_{(z)} - (Z)_{(2)}\left[1 - \Phi_{(z)}\right] = 0{,}036 - (2{,}178 \times 0{,}0147) = 0{,}0052$$

$$SS_P = Z \times \sigma_{T+L} = 2{,}178 \times 14.292 = 31.133{,}18 \approx 31.134 \text{ unit}$$

$$I_{max} = SS_P + d\,(T_{(Daily)} + L) = 31.134 + 1.290\,(31 + 5) = 77.570{,}72 \approx 77.571 \text{ unit}$$

$$N_P = \sigma_{T+L} \times L_{(z)} = 14.292 \times 0{,}0052 = 74{,}26 \approx 75 \text{ unit}$$

$$TIC_P = \left(\frac{1}{T_{(Year)}}\right) S + \left(\frac{D \times T_{(Year)}}{2} + SS_p\right) H + \left(\frac{1}{T_{(Year)}}\right)(C_S \times N_P)$$

$$TIC_P = \left(\frac{1}{0{,}116}\right) 131.706 + \left(\frac{340.536 \times 0{,}116}{2} + 31.134\right) 64 + \left(\frac{1}{0{,}116}\right) \times (504 \times 75) = \text{Rp}4.718.460$$

- For 600 mL

$$T_{(Year)} = \frac{Q_3}{D} = \frac{18.866}{169.992} = 0{,}1109 \text{ Year}$$

$$T_{(Daily)} = 0{,}1109 \times 264 = 30 \text{ Days}$$

$$\sigma_{T+L} = \sigma_d \times \sqrt{T_{(Daily)} + L} = 805 \times \sqrt{30 + 5} = 4.762{,}44 \approx 4.763 \text{ unit}$$

$$P_{(z)} = \frac{H \times T_{(Year)}}{C_S} = \frac{136 \times 0{,}1109}{508} = 0{,}029$$

$$\Phi_{(z)} = 1 - P_{(z)(2)} = 1 - 0{,}029 = 0{,}97$$

$$(Z) = 1{,}885 \text{ (from Z-table)}$$

$$L_{(z)} = \varnothing_{(z)} - (Z)_{(2)}\left[1 - \Phi_{(z)}\right] = 0{,}066 - (1{,}885 \times 0{,}029) = 0{,}0115$$

$$SS_P = Z \times \sigma_{T+L} = 1{,}885 \times 4.763 = 8.978{,}48 \approx 8.979 \text{ unit}$$

$$I_{max} = SS_P + d\,(T_{(Daily)} + L) = 8.979 + 644\,(30 + 5) = 31.515{,}81 \approx 31.516 \text{ unit}$$

$$N_P = \sigma_{T+L} \times L_{(z)} = 4.763 \times 0{,}0115 = 54{,}73 \approx 55 \text{ unit}$$

$$TIC_P = \left(\frac{1}{T_{(Year)}}\right) S + \left(\frac{D \times T_{(Year)}}{2} + SS_p\right) H + \left(\frac{1}{T_{(Year)}}\right)(C_S \times N_P)$$

$$TIC_P = \left(\frac{1}{0{,}1109}\right) 131.706 + \left(\frac{169.992 \times 0{,}1109}{2} + 8.979\right) 136 + \left(\frac{1}{0{,}1109}\right) \times (508 \times 55) = \text{Rp}3.942.521$$

Based on the results of the Periodic Review System calculations, the inventory parameters for both product sizes are obtained. For the 330 mL product, P is 0,0147. In addition, SS_P is determined to be 31.134 units, and I_{max} is 77.571 units. N_P is calculated at 75 units, resulting TIC_P of Rp4.718.460. Meanwhile, for the 600 mL product, P is 0,029, with SS_P of 8.979 units and I_{max} of 31.516 units. N_P for this product is 55 units, which resulting TIC_P of Rp3.942.521. The final results of all these calculations are summarized in Table 1.

Table 1. Recapitulation of Results

No	Description	Packaging Size	Q-System	P-System
1	Safety Stock	330mL	11.605	31.134
		600mL	3.395	8.979
2	Expected Shortage	330mL	28	75
		600mL	21	55
3	Total Inventory Cost	330mL	Rp3.263.832	Rp4.718.460
		600mL	Rp3.027.468	Rp3.942.521
4	Cost Savings/Reduction	330mL	33,62%	4,04%
		600mL	25,75%	3,30%

The evaluation reveals that TIC_{actual} reaches Rp4.916.910 for the 330 mL variant and Rp4.077.156 for the 600 mL variant. This high expenditure is a direct consequence of a rigid operational policy that dictates a fixed, remarkably small order size (Q_{actual} = 9.600) units for every single purchase setup. By relying purely on intuition, this baseline method forces the company into a hyper-frequent ordering cycle (e.g., 35 orders per year for the 330 mL variant), causing severe inflation in annual ordering costs. Furthermore, this traditional method completely ignores real-time demand fluctuations, which actually exhibit a daily standard deviation of 2.382 units for the 330 mL size and 805 units for the 600 mL size. This misalignment demonstrates that underestimating optimal order quantities to suppress physical holding costs ultimately backfires with massive set-up expenses, as relying on manual inventory management and poor demand forecasting inevitably triggers severe supply chain imbalances (Adama & Okeke, 2024; Olutimehin et al., 2024). Such static and intuition based planning creates significant cost inflation and operational inefficiencies within a dynamic consumer goods market.

To address the inefficiencies of the baseline method, Q-System emerges as the most financially superior alternative in this study. The optimization results reveal that implementing the Q-System significantly reduces the total inventory cost to Rp3.263.832 (a 33,62% cost saving) for the 330 mL variant and Rp3.027.468 (a 25,75% cost saving) for the 600 mL variant. This substantial cost reduction is primarily achieved because the system maintains a relatively small safety stock only 11.605 units for the 330 mL size and 3.395 units for the 600 mL size. Through the use of mathematical iterations, the Q-System balances this low holding cost with a ROP to prevent expensive shortage penalties. Although this method demands the effort of continuous daily stock monitoring, the financial savings prove to be highly rewarding for the company (Ernawati et al., 2025). Utilizing this continuous tracking and ROP-based replenishment mechanism is proven to be an effective strategy for minimizing total inventory costs and reducing average holding levels while securing product availability (Gomes et al., 2023).

In contrast to the high efficiency of the Q-System, the implementation of P-System yields a remarkably lower cost performance, reducing the total inventory cost by only 4.04% for the 330 mL variant and 3.30% for the 600 mL variant. The mathematical data reveals that this minimal saving is a direct consequence of a drastic surge in SS_P, which climbs to 31.134 units for the 330 mL size and 8.979 units for the 600 mL size. This accumulation represents nearly a threefold increase compared to the Q-System requirements. This phenomenon occurs because the P-System only checks inventory levels at fixed intervals, specifically 31 days for the 330 mL and 30 days for the 600 mL, creating a temporary lack of visibility during the protection period. To compensate for this unmonitored gap and eliminate the risk of stockouts, the model is forced to accumulate a much larger stock buffer, as extending the review interval mathematically demands significantly more spare items to maintain adequate service levels (Giat, 2024). While a periodic approach offers administrative ease in delivery scheduling, it creates a severe financial burden when applied to fast-moving consumer products with dynamic turnover rates.

Synthesizing the results of this comparative analysis, it becomes evident that relying on intuition or rigid periodic checks is no longer sustainable for PT XYZ. The massive cost discrepancy between the evaluated methods proves that the company must adopt a more dynamic and data-driven approach to survive in a fluctuating market. Therefore, this study recommends that the management transition its inventory policy from the current baseline method to Q-System for both the 330 mL and 600 mL product lines. By implementing the Q-System, the company can actively monitor its stock levels and consistently order the precise optimal quantity. This strategy will secure the company's operations against expensive stockout penalties while keeping physical holding costs at an absolute minimum. This research fulfills its primary objective by demonstrating that the application of a probabilistic iterative calculation is not merely a theoretical concept, but a vital operational necessity for achieving true financial efficiency in the fast-paced bottled water industry.

CONCLUSION

This study aimed to determine the most cost-efficient inventory control method for PT XYZ by comparing the Q-System and the P-System using a probabilistic iterative algorithm. The mathematical evaluation demonstrates that the company's current intuition-based policy is highly inefficient, resulting in inflated annual expenditures. When tested on the 330 mL and 600 mL bottled water variants, the Q-System emerged as the preferred model. While the P-System only generated marginal savings of less than 4,04% due to a massive surge in safety stock required to cover unmonitored review intervals, the Q-System reduced TIC by 33,62% and 25,75%, respectively. It achieved this by maintaining a much smaller, yet highly secure, safety stock through continuous daily tracking and calculated reorder points. This research concludes that adopting the Q-System is the optimal strategy for PT XYZ, answering the initial research objective by providing a data-driven policy that minimizes physical holding costs while eliminating the expensive risk of stockouts in a volatile market. It is recommended to incorporate supplier lead time variability and multi-item joint replenishment scenarios to further enhance the robustness of the probabilistic inventory model.

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